SURFACE WATER QUALITY IN THREE INTERDUNAL PONDS, SOUTH END PONDS ECOSYSTEM, CUMBERLAND ISLAND, GEORGIA

Thomas R. Kozel

AUTHOR: Thomas R. Kozel, Department of Biology and Life Sciences, Savannah State College, Box 20483, Savannah, Georgia 31404.
REFERENCE: Proceedings of the 1991 Georgia Water Resources Conference, held March 19 and 20, 1991 at The University of Georgia. Kathryn J. Hatcher, Editor, Institute of Natural Resources, The University of Georgia, Athens, Georgia 1991.

INTRODUCTION

Data collection to determine the surface water quality of three shallow interdunal ponds at the extreme southern tip of Cumberland Island National Seashore, Cumberland Island, Georgia has been in progress for more than two years. A brief summary for the interval 14 Apr 88 - 25 Feb 89 was reported previously by Kozel (1989). The principal objective of this project is to obtain, over a five-year period, baseline data on depth and fourteen water chemistry parameters in these ponds. The information obtained will be used to characterize the spatial and temporal fluctuations in surface water quality which are of seasonal and/or annual significance in the ecosystem. Channel dredging in Cumberland Island Sound adjacent to the ponds area has raised concerns within the National Park Service that the confined aquifer beneath the ponds might be breached with subsequent effects on the ponds' water quality; and/or that shoreline erosion might modify the volume of sound water known to enter two of the ponds on high spring tides. Interdunal ponds have received little scientific attention (Odum and Harvey, 1988), but study of the South End Ponds of Cumberland Island is especially important because the endangered wood stork, Mycteria americana, forages on fishes and amphibia in them. Water quality affects the availability of such forage organisms for the birds.

This paper reports the results of data collected on depth and fourteen water chemistry parameters in the three South End Ponds from 14 Apr 88 - 26 May 90. Recently, Cofer-Shabica, and others (pers. comm., 1990), have begun to gather data on groundwater hydrology in the ponds' area and this information, combined with the surface water chemistry data, should provide a fair description of the hydrology and water chemistry of the South End Ponds ecosystem.

MATERIALS AND METHODS

For comparison with other U.S. east coast interdunal ponds, the three South End ponds were characterized on the basis of their average salinity and vegetation: (1) freshwater pond (0.4 o/oo); (2) high salinity pond (18.8 o/oo) and (3) low salinity pond (8.1 o/oo). The surface area of the ponds was approximately 1.2, 0.12 and 0.25 ha respectively at the beginning of the study (Fig.1). Three sampling stations were established in each of the ponds and samples were collected and analyzed monthly from each of the stations. In the freshwater pond one sampling station was established near the southeastern margin of a large Typha sp. stand, and two others at locations which partitioned the remaining open water into equal compartments. Stations in the saline ponds, which had little obvious habitat heterogeneity, were positioned to divide them into equal sections. Standard techniques for the collection and analysis of water samples were used (Standard Methods, 1985; Hach, 1987). See Kozel (1989) for additional details.

RESULTS AND DISCUSSION

The freshwater pond contained water during the fall, winter and early spring months and became progressively drier during the summer due to high evaporative rates. Rainfall was the source of water for this pond. During 1989, the only water remaining was near Stn 2 in a small alligator pit. Vegetation characteristic of drier sites began to cover the pond bottom. The greatest depth observed in the freshwater pond was 549 mm during Apr 88. The volume of the high salinity pond shrank dramatically during the summer months, but some water always remained. An alligator pit, about 2 m deep, was also present in this pond, along the south margin. Spring tides during the spring and fall season contributed the bulk of the water to this pond. The greatest depth observed (not including the alligator pit) was 517 mm in Apr 88. The low salinity pond became almost dry toward the end of each summer season and received water from the nearby sound during extreme spring tides coupled with onshore winds. The greatest depth observed in this pond was 462 mm in Apr 88. Rainfall contributed some water throughout the year to both the high and low salinity ponds.

For the fourteen water chemistry parameters, the freshwater pond will be referred to as (1), high salinity pond (2) and the low salinity pond (3). ANOVA revealed no statistical differences between stations within the same pond for any parameter over the sample period ($p = 0.05$).

TABLE 1. Water Temperature (C)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	23.6	9.8	37	10
(2) High Salinity	25.8	9.1	37	10
(3) Low Salinity	25.6	9.5	40	11

Surface water temperatures (Table 1) varied with the seasons and usually were observed to be within one or two degrees of the ambient air temperature. Shading by floating macrophytes such as Lemna and Ceratophyllum produced lower water temperatures a few cm below the surface. Dark brown sediments in (3) probably enhanced water temperatures in the shallow water.

TABLE 2. Alkalinity (mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	59.1	48.1	232	0
(2) High Salinity	66.7	27.1	120	14
(3) Low Salinity	59.8	23.7	107	10

Peak phytoplankton growth were the greatest. Alkalinity values in the saline ponds varied with the influence of spring tides. In all ponds, the lowest values were recorded from Sep 89, when a large amount of rainfall entered the ponds shortly before the sampling date.

TABLE 3. Chemical oxygen demand (COD in mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	69.9	32.4	110	27
(2) High Salinity	58.1	41.8	134	12
(3) Low Salinity	74.7	24.1	107	28

COD (Table 3) in (1) generally increased with increasing vegetatioin abundance, reaching its greatest values in late summer. Tidal flushing in (2) and (3) usually occurred in Mar and Sep/Oct so this pattern was preserved in them also. Due to the heavy rainfall input in Sep 89 the lowest values were observed at that time. Linear regression analysis of COD and suspended solids showed a significant positive correlation ($p= 0.05$) between the two parameters. Linear regression analysis of COD and turbidity also showed a significant positive correlation ($p= 0.05$) between the two parameters.

Color in the freshwater pond ranged from clear to a tea color. Color intensity increased in the fall and winter of the year when leaf fall input contributed tannins to the system. In the saline ponds the color ranged from clear to slightly yellow or yellow-tan. Color increased as in (1) but tidal flushing prevented the deep tans and browns from developing.

TABLE 4. Conductivity (micromhos/cm^2)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	1256	961	2650	184
(2) High Salinity	26812	13333	>50000	1770
(3) Low Salinity	11938	13440	>50000	2500

Conductivity (Table 4) in (1) was highest during the summer when the pond was almost dry except for an alligator pit near Stn 2. Presumably, ions were concentrated at this time due to evaporation rates. The presence of feral horses foraging in (1) contributed to conductivity also, due to the addition of relatively large amounts of fecal material and urine. Salt spray also contributed some conductivity to (1). The lowest conductivity values were recorded from all three ponds in Sep 89 after the large rainfall input. The exceptionally low values seen in (2) and (3) in Sep were the result of sampling the surface lens of almost fresh water layered upon the denser saline water beneath. Conductivity in (2) and (3) varied with the influence of spring tides. Some input from horses is probable, but their usage of the saline ponds was lower than that of the freshwater pond.

TABLE 5. Dissolved Oxygen (mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	8.3	2.7	12.2	4.2
(2) High Salinity	10.5	2.7	16.1	3.4
(3) Low Salinity	8.8	2.1	13.3	4.0

Maximum dissolved oxygen (Table 5) values were observed during peak photosynthetic periods. Much phytoplankton and attached benthic algae was occasionally observed. Low values were recorded in pools during periods of high evaporation. Mixing due to tidal flushing contributed dissolved oxygen to the saline ponds.

TABLE 6. Ammonia (NH_3N in mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	1.79	2.34	11.5	0.14
(2) High Salinity	1.59	1.74	5.64	0.27
(3) Low Salinity	1.69	1.97	7.50	0.16

Ammonia nitrogen (Table 6) was highest in all three ponds during the summer periods of high evaporation and reduction in pond volume. Lowest values were noticed during the late fall and winter in each of the ponds. Decomposition during periods of high water temperatures and low water volume is reflected in the high ammonia nitrogen values observed.

TABLE 7. Nitrite (NO_2 in mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	0.014	0.041	0.16	0
(2) High Salinity	0.005	0.004	0.019	0.001
(3) Low Salinity	0.004	0.005	0.06	0

Nitrite nitrogen (Table 7) values were highest in (1) during the summer in pools remaining during periods of high evaporation. The highest values observed in the saline ponds were in Sep 89 after the influx of fresh rainwater. Values in these ponds were generally low at other periods of the year. Nitrite is usually observed at low levels in natural waters because of its intermediate position between NH_3N and NO_3N.

TABLE 8. Nitrate (NO_3 in mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	0.11	0.19	1.5	0
(2) High Salinity	0.39	0.28	1.3	0
(3) Low Salinity	0.42	0.52	1.5	0

Nitrate nitrogen (Table 8) peaks in (1) occurred in Jun 88, Jan 89, Sep 89 and Apr 90. Many zero values were reported. No particular pattern of occurrence can be discerned at this time. Two peaks in (2) occurred in July of each year and one peak was observed in Mar 90. Two peaks also occurred in (3) during July of each year. Minimum readings were quite erratic and showed no particular pattern.

TABLE 9. Phosphate (PO_4 in mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	2.04	1.14	5.52	0.33
(2) High Salinity	1.07	0.52	2.20	0.38
(3) Low Salinity	1.04	0.65	2.10	0.11

Orthophosphate (Table 9) levels exhibited two peaks in (1). One peak occurred during the summer as the ponds shrank in volume. This was possibly a concentration effect. A second, and higher, peak occurred during the late fall and winter. This was possibly the result of macrophyte and phytoplankton decomposition releasing phosphorus to the water column. Water temperatures never fell below 10 C so some decomposition was occurring all year. Similar, but lower peaks were observed in the saline ponds, but the exact timing was modified somewhat due to tidal flushing. The high orthophosphate content of waters from all three ponds indicates that they are highly eutrophic. This conclusion is supported by the relatively high NO_2 + NO_3 values obtained, and by observing the large numbers of macrophytes in ponds (1) and (3) and the algae sometimes present in (2).

TABLE 10. pH

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	7.1	1.1	9.7	4.0
(2) High Salinity	8.1	0.6	9.4	7.0
(3) Low Salinity	7.6	0.7	9.0	5.5

The pH (Table 10) in each of the ponds was generally on the alkaline side. The average pH in the saline ponds was slightly higher than in (1) as expected, and also showed somewhat less variation during the sample period. pH values in (1) peaked during periods of greatest photosynthesis. The lowest value in (1) occurred after the Sep 89 influx of rainfall. One can speculate that the rainfall was acidic and that the buffering capacity of (1) was less than that in (2) and (3) and that is why they showed less fluctuation at that time. The pH in (2) actually rose 0.3 compared with the previous month, but some tidal influence also occurred.

TABLE 11. Salinity (o/oo)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	0.4	0.6	2.1	0
(2) High Salinity	18.8	9.8	>40	0.9
(3) Low Salinity	8.1	9.9	>40	1.2

Salinity (Table 11) in the freshwater pond was usually low or zero. The maximum value occurred in Jul 89 in the alligator pool. Concentration effects and salt spray are likely to explain the value observed. Salinity in the two saline ponds fluctuated with the input of spring tidal water and rose during periods of high evaporation. The lowest salinity values in each of the ponds occurred in Sep 89 following the high rainfall period.

TABLE 12. Suspended Solids (mg/1)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	127	58.8	214	42
(2) High Salinity	89	68.3	265	20
(3) Low Salinity	89	52.5	184	38

Suspended solids (Table 12) in each pond generally exhibited summer peaks and winter lows. Using linear regression, this parameter was positively correlated ($p=0.05$) with COD and turbidity in each of the ponds. Suspended solids was associated with phytoplankton abundance.

TABLE 13. Turbidity (NTU)

Pond	Mean	S.D.	Max.	Min.
(1) Fresh	47	56.5	225	3
(2) High Salinity	26	26.2	109	2
(3) Low Salinity	13	13.1	58	2

Turbidity (Table 13) exhibited a summer peak in each of the ponds and a secondary Jan 89 peak in (1) and (2). Lows usually occurred during the winter months. Turbidity was associated with phytoplankton abundance and also with the movement of horses through the ponds causing mixing of the substrate and water column. The relationship between turbidity and COD and suspended solids was noted above.

CONCLUSIONS AND RECOMMENDATIONS

Overall the ponds exhibited a high degree of variability with respect to many parameters, even pond surface area. Possible influences range from meteorological effects such as precipitation, and evaporation to subtle effects such as horse movement through the water. Some parameters exhibited seasonality and some were strongly influenced by periods of heavy rainfall. Tidal input affected the saline ponds. The presence of feral horses contributed to variation in some of the parameters, especially PO_4 and possibly turbidity. The following preliminary management recommendations are made: 1) Monitoring of the ponds should continue until enough data is collected to be certain of the trends now beginning to be discerned. At some point it should be possible to discriminate between natural influences and human-induced changes in the ponds. Data from the groundwater study will compliment the surface water chemistry data. It is too early to tell whether dredging has influenced water quality in the ponds. 2) Meteorological and depth data from the freshwater pond indicate that the average depth of this pond has decreased since Apr 1988. This has caused the loss of the mosquitofish, Gambusia a. holbrooki, from the pond. If increasing forage potential for the woodstorks is a management goal, the pond morphometry could be altered so that more water might be retained. 3) Eutrophication could be slowed in the freshwater pond by preventing the feral horses from entering it.

ACKNOWLEDGMENTS

Grant support was from the Rutgers Univ./Nat'l Pk. Serv./HBCU Res. Collab. Special thanks to Cumb. Isl. Nat'l Seas. personnel, Sch. of Sci. & Tech. Sav. State Coll., I. Awan, J. Throne & J. Richardson.

LITERATURE CITED

American Public Health Association, 1985. Standard Methods For the Examination of Water and Wastewater, 16th ed. Amer. Public Health Assoc., Washington, D.C., 1267 pp.

Hach, 1987. Hach Water Analysis Handbook. Hach Co., Loveland, CO, 370 pp.

Kozel, T.R., 1989. Water Quality in the Three South End

Ponds, Cumberland Island, Georgia. Proceedings of the 1989 Georgia Water Resources Conference, 16-17 May 1989, Univ. of Georgia. Kathryn J. Hatcher, ed.

Odum, W.E. and J.W. Harvey, 1988. Barrier Island Interdunal Freshwater Wetlands. Assn. Southeastern Biol. Bull. 35(4): 149-155.